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FUTURE WATER RESOURCES MANAGEMENT ISSUES AND THE STRATEGIES AND POLICIES THAT THE INTERNATIONAL COMMUNITY SHOULD BE CONSIDERING IN RESPONSE

Inter-sessional strategy paper of the Committee on Natural
Resources on future water resources management issues and
appropriate strategies and policies

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INTRODUCTION

1. The present inter-sessional strategy paper was prepared by the members of the Committee on Natural Resources under the leadership of Ms. Malin Falkenmark, in accordance with a decision made by the Committee at its second session.

2. The world community is currently struggling with the widespread symptoms of the mismanagement of land and water by previous generations. An array of international programmes are addressing water-related issues one by one. At the same time, rising expectations and unavoidable population growth - both major societal driving forces - are leading the world towards a severe water crisis. By 2025, more than one third of the world population will be living in countries that are water stressed or have chronic water scarcity. Constraints to social and economical development strategies will appear and will have to be reckoned with in national planning, possibly imposing unforeseen and unwanted limitations on economic development, self-reliance in food, health, industrial development etc.

3. The imminent crisis propels the water issue onto the international political agenda alongside global climate change, which has already attracted massive national and international interest although it is in fact a more distant prospect: the water crisis is an even higher priority due to its shorter time horizon. Urgent action of a new type is needed to ensure that water's deep involvement in both environment and development issues can be properly addressed, action that will demand an integrated approach to land use, water-supply and waste management, with due attention to all water's parallel functions in nature and society, as well as to the evident linkages between upstream land and water use and downstream opportunities. The most evident unit for such integration is the catchment or river basin.

4. Governments' participation will be crucial to make the management revolution possible. Their particular responsibilities to society include:

(a) To make such management possible by providing adequate legal rules, capable administration, integrated regional planning and encouragement of local action;

(b) Securing the human capability development that will be necessary for its implementation;

(c) Agreeing on ethical rules and the general approach to hydrographic interdependencies. Since the problem is generic in character, it is shared by all countries. What varies is the composition of the problem clusters, according to differences in hydroclimate, soil vulnerability, and the level of socio-economic development and multilateral dependence.

5. International cooperation is essential to identify a diagnosis for the overall problem: what is at stake, the international actions needed and the water ethics that could provide guidance. Since global food security is closely linked to water availability, such issues should be properly linked. The following strategic policy responses are urgently needed:

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- (a) Acknowledging non-negotiable constraints, linkages and interdependencies;
- (b) Developing ethical rules for international guidance;
- (c) Conflict mitigation measures;
- (d) Preparedness for environmental migration;
- (e) Addressing short-term and long-term issues in parallel;
- (f) Making it possible to take an integrated approach to land and water management within existing hydrographic boundaries.

I. WHY IS THE MANAGEMENT OF WATER RESOURCES A CRUCIAL ISSUE?

A. Imminent massive water crisis

6. Among the international programmes that are currently addressing water-related issues, the United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa, focuses on soil problems in dry regions where water is scarce; the debate on land-based sources of marine pollution draws attention to water's role as a mobile carrier of pollutants from land to rivers and coastal waters; the debate on world food security draws attention to the key role of water in food production; and since the United Nations Water Conference (Mar del Plata, 14-25 March 1977), huge efforts have gone into safe water-supply and sanitation, although unfortunately the net effect of the Conference has been partly offset by population growth.

7. The world is facing a severe water crisis: by 2025, 52 countries with a total population of more than 3 billion people will be plagued by water stress or chronic water scarcity. ^{1/}

8. Politicians are caught between the legacy from past mismanagement of natural resources on the one hand, and future obligations to a rapidly growing world population on the other. If not averted in time, such a water crisis will have severe repercussions on human health, global food supply and nutrition, the eradication of poverty, human dignity and quality of life, and environmental security and peace, to say nothing of ecosystem health and biodiversity.

B. Need for high-level political involvement

9. A new kind of action will be called for. To approach the crisis as merely a technical water management issue, in the conventional fragmented way would actually aggravate the situation; regional political involvement at the highest level of government will be needed to articulate a national water resources strategy that is fully integrated into national planning.

10. The water crisis is an even higher priority than global climate change due to its shorter time horizon: the mothers are already born and population growth effectively unavoidable. It is a question of how much politicians need to know before they act with equal decisiveness on the imminent crisis in world water resources.

11. One international document after the other has expressed more or less direct and explicit warnings of the impending crisis at the United Nations Water Conference in 1977, the International Conference on Water and the Environment and the United Nations Conference on Environment and Development in 1992, and the first session of the Committee on Natural Resources and the Stockholm Water Symposium in 1993. Unfortunately, high-profile international commissions have largely ignored the issue; the Brundtland report, Our Common Future, 2/ is a notable example.

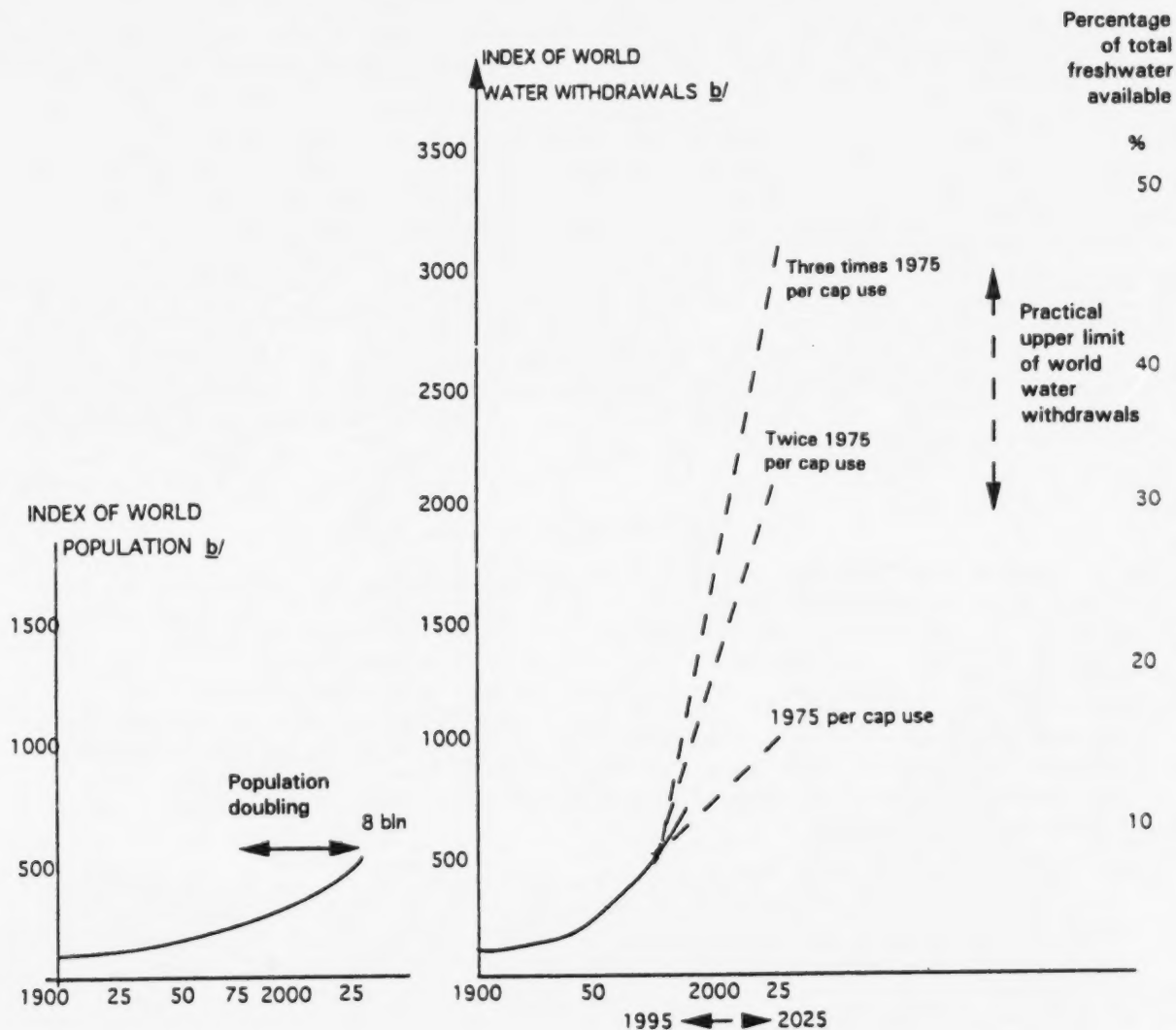
12. The present inter-sessional strategy paper attempts to define the crisis, its implications, and the basic strategies needed to avoid the risk for societal retardation that it involves.

C. Four main components of the water crisis

13. During the twentieth century, the supply of water to various sectors of society has increased about two and a half times faster than the population growth. A continuation of that trend will not be realistic (see fig. 1). The amount of water available is finite and the most accessible sites for the construction of dams and reservoirs have already been appropriated. In addition, the costs of building additional storage facilities and conveyance systems are soaring, and attempts to recover costs have so far met with little progress; financial constraints are contributing to a revision of previous policies; and many contemporary projects are being questioned by vocal environmental movements.

14. The issues that will dominate water management in the twenty-first century are increasing population pressure on a finite water resource; impacts on that resource generated by climate change; intersectoral disputes; environmental migration; and international controversies and wars. The implications of a full-fledged water crisis are much more severe than most politicians seem willing to acknowledge (see table 1).

Figure I. Where are we heading? a/



Source: I. A. Shiklomanov, "World freshwater resources", in Water in Crisis, P. Gleick, ed. (Oxford University Press, 1993).

a/ Tendencies 1900-2025 of population growth (left) and gross world water withdrawals (right), as compared to practical upper limit of water withdrawals: three projections for the period 1975-2025, during which world population will approximately double: unchanged, doubled and trebled 1975 per capita use.

b/ Time stable flow; 1900 values given as index 100.

Table 1. Fourfold water crisis: threats and risks

Problem	Cause	Threat	At stake
Water quantity crisis	Finite resource	Increasing disputes and conflicts	Development
	Escalating demands		Peace
			Food security
Water quality crisis	Expanding water pollution	Increasing morbidity/mortality	Human health
			Aquatic ecosystems
Urban scale/water supply crisis	Urban growth out of control	Social unrest	Social order
		Persisting poverty	Overall development
Land fertility degradation crisis	Degradation of soil permeability/water holding capacity	Decreasing crop yields/agricultural production	Food security
	Erosion		

1. The water quantity crisis

15. The water quantity crisis has several faces. Many poverty-stricken low latitude countries with rapid population growth, high illiteracy and large deficiencies in terms of trained manpower suffer from a complex water scarcity, in the form of particularly problematic environmental conditions with which they must cope, such as monsoon climates, erratic rainfall and poor soils. The number of individuals living in water-stressed countries or countries with a chronic water scarcity will increase tenfold in only one generation to encompass more than one third of the world population. ^{3/} In waste areas, there has been an overexploitation of aquifers, which are becoming ever more seriously depleted. ^{4/} The risks that threaten to erupt wherever socio-economic development depends on a continuously undermined key resource are evident: ultimate resource constraints will one day send shocks through such vulnerable societies.

2. The water quality crisis

16. The water quality crisis is the result of the poor handling of the waste that attends human activities. Except for certain pollutants for which waste water treatment has been successful in more advanced regions, water pollution continues to increase. ^{5/} All water soluble pollutants are spread with the water cycle and the sea currents. Indeed, there is no more pristine water left: human pollutants are found even in Antarctic waters.

3. The urban scale and water-supply crisis

17. The urban scale and water-supply crisis is linked to the fact that urban growth is more or less out of control in many third world regions. The growth is exacerbated by the rural push - the exodus of poor population strata from marginal areas where it is not considered possible to make a dignified living. Municipal authorities face increasing difficulties in supplying the infrastructure needed to provide safe water and sanitation. As an illustration, Beijing's future as a capital of China has actually been questioned. Many systems carry water only a few days a week. There are exaggerated expectations for the Government to supply household water. Water-supply systems are often in bad shape, seriously cracked with large-scale leakages, so that they can easily be contaminated by pollutants from equally cracked sewage pipes. Moreover, the possibility of bringing more water to the city is often limited by landscape hydrology and the escalating costs involved in long-distance water transfers.

4. The land fertility degradation crisis

18. The land fertility degradation crisis has many water-related causes, such as soil erosion, salinization and waterlogging from poorly managed irrigation, and acidification. 6/ Current expectations in terms of increase of crop production may prove unrealistic: economists sometimes overlook biophysical constraints, and many analysts tend to neglect changes in the resource base. Although the Food and Agriculture Organization of the United Nations (FAO) expects crop production in sub-Saharan Africa to be 3 per cent per year during the period 1990-2010, other estimates suggest that due to ongoing land degradation, a more probable growth rate is 0.5 per cent per year. 7/ Such a shortfall could result in massive starvation.

D. Impact of water crisis on key societal sectors

19. Water affects human activities in many parallel ways:

(a) As a life necessity in the form of the daily need for household water. The threat lies in collapsing water-supply systems in cities and escalating pollution in existing systems;

(b) As a habitat for fish and seafood, an important base for food and protein supply. The threat lies in such a foodstuff acting as a disease vector;

(c) As a key resource in agriculture. In rain-fed agriculture, the threat lies in land degradation, involving the formation of impermeable crusts; in irrigated agriculture, the threat lies in the degradation of water by upstream activities, as well as in waterlogging and salinization destroying land productivity due to the poor operation and maintenance of irrigation systems;

(d) As a key resource in socio-economic production, especially water for industrial processes, since pollution of accessible water may impoverish vulnerable industry and a lack of usable cooling water may destroy sensitive computer equipment etc.;

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(e) As a key resource for hydropower-based energy supply. The threat lies in the fact that the river flow may be reduced by upstream land-use activities that consume water and return it to the atmosphere so that it is not available for reuse.

With all the four crises described above characterizing the present situation, human society is indeed threatened in several ways in parallel: the drinking-water supply and health of future generations, the food security of the world population, the health of aquatic ecosystems, biodiversity, societal production and thus the potential for both the eradication of poverty and economic development are all threatened (see table 2).

Table 2. Sectoral breakdown of the water crisis

Sector hurt	Water function involved	Cause	Risk
Drinking water-supply	Health	Water pipe degradation	Increasing morbidity and mortality
		Water pollution continues to expand	
		Agricultural chemicals	
Food production	Production factor	Availability constraints	Famines
		Expansion of consumptive use	Environmental migration
Aquatic ecosystems/ biodiversity	Habitat	Expanding water pollution	Biodiversity degradation
Retardation in societal production	Production factor	Finite availability	Societal retardation in dry climate regions
		Growing demands	
		Increasing sector competition	

20. The current food supply and environmental crisis is probably the most serious crisis ever faced by humanity, and its origin is the water crisis. The threat to regional food self-reliance and overall food security is particularly serious because it seems to be poorly acknowledged. What is needed in South Asia and sub-Saharan Africa - two subregions suffering from both complex water scarcity and large-scale land degradation - is nothing less than a production revolution, larger even than the first green revolution, a super green revolution. 8/ In some regions, industrial development may be delayed due to problems of water-supply, escalating pollution and groundwater overexploitation. In others, competing claims for additional water may be incompatible, such as

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when upstream use expands at the expense of downstream use, or when urban supplies will be favoured at the expense of rural provisions.

II. WHERE DO WE START?

A. Multi-cause syndrome of environmental change

21. To safeguard the future of their societies, Governments are facing formidable challenges. The current situation has grown out of a number of parallel causes:

(a) Pollutants have been introduced into water pathways, degrading water quality;

(b) Land-use related manipulations of water flow determinants have caused changes in flow regimes (river flow, floods, dry season flows);

(c) Manipulations with soil and vegetation in regions with vulnerable soils have caused land impermeability and therefore lack of soil moisture (so-called desertification);

(d) Poor management of irrigation systems has caused waterlogging and salinization of fertile soils.

While administration has been fragmented on all levels, with different water issues being addressed by different authorities, there has often been a lack of a comprehensive overview to compensate for such fragmentation.

22. Two fundamental questions that must be addressed are:

(a) What in man's relations to this vital resource is non-negotiable and must unavoidably be adapted to?

(b) What is negotiable and can be altered? Governments will be helped by understanding the differences, acknowledging non-negotiable constraints in working out new management models based on what is indeed negotiable. 9/

B. Non-negotiable constraints

23. A number of water-related phenomena are non-negotiable in the sense that they result from laws of nature guiding the circulation of freshwater around the globe. Since prehistoric times, such phenomena have been mitigated and compensated for by technological and management measures.

1. Hydroclimatic realities

24. The hydroclimate is governed by the atmospheric circulation, and is subject to large regional differences in terms of precipitation (amount, seasonality, predictability, inter-annual variability etc.); evaporative demand, which

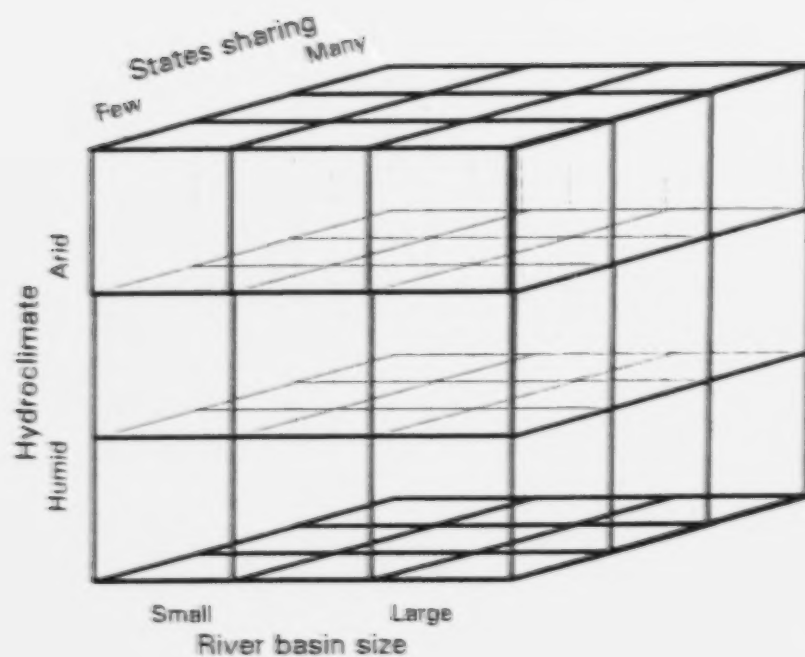
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regulates the amount returning back to the atmosphere as evaporation and plant transpiration; and the remaining water surplus recharging aquifers and rivers.

2. Hydrographic realities

25. The hydrographic pattern marks the delineation of river basins, whereas the political boundaries define the number of countries that have to share its water (see fig. II). Dependency on international cooperation varies considerably between the extremes represented by a small river basin in a dry climate region shared by many different countries, on the one hand, and a large river basin in a humid region enclosed in one single country, on the other.

Figure II. Non-negotiable preconditions influencing international dependency among countries sharing a river basin



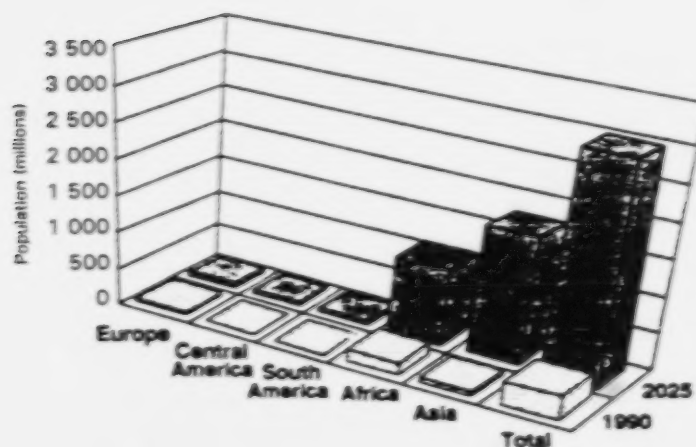
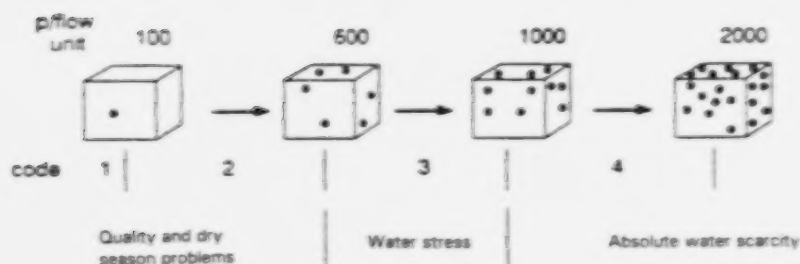
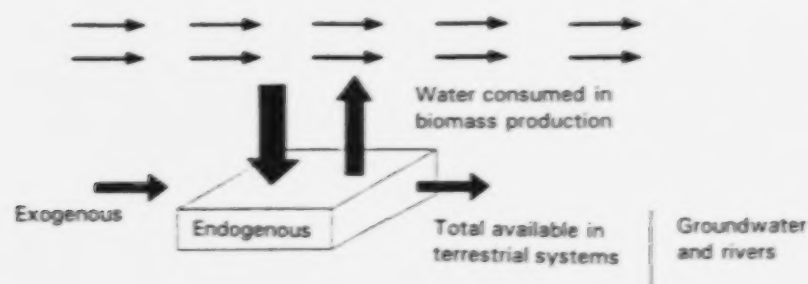
3. Constraints in water availability

26. The water availability of a country varies with its climatic position, geology and hydrography. The hydroclimate determines the run-off produced from rainfall within the territory, and the hydrography determines the inflow of run-off produced from upstream rainfall in the same river basin.

27. The amount of water available in rivers and aquifers can basically be seen as a certain number of flow units of water (for example, 1 million cubic metres per year). It varies between wet and dry years, but in a stable climate the long-term average is constant and finite. The size of the population defines the population pressure on that amount (i.e., the average number of citizens that jointly depend on each flow unit of water; see fig. III). Whether a high population pressure gives rise to manifested water stress or not depends on the actual level of living and water requirements.

28. All the water available may not be accessible, however, due to seasonality and inter-annual fluctuations. Natural availability characteristics can be modified by reservoirs, pipelines, canals etc. Constraints in the accessibility and utility of safe freshwater are aggravated wherever the resource is affected by water consumption in upstream countries, increasing pollution of entire water systems, depletion and pollution of aquifers, and deforestation and urban development.

Figure III. Water availability as seen on a regional scale ^{a/}



Source: M. Arnestrand, Royal Institute of Technology, Sweden.

^{a/} Upper figure illustrates water availability, as composed of an endogenous component emerging from rainfall over the country and an exogenous component emerging from rainfall over upstream countries; middle figure visualizes growing population pressure on a finite availability, each cube representing one flow unit of 1 million cubic metres per year, each dot 100 persons jointly depending on that water; lower figure indicates number of people living in water stressed countries by 1990 and 2025 (more than 600 per flow unit of available water) with columns showing different continents and the gross total.

4. Two-way land/water linkages

29. Given water's many parallel functions, most land-use activities are water-dependent. The demand for water is rising rapidly for agriculture, energy generation, industrial production and urban consumption. Due to water's two carrying functions (carrier of both solutes and silt), most land use also affects water.

30. For the first reason, water conditions provide constraints to water-dependent land use. Rice can only be grown where there is plenty of water. For crop yields to be optimal, there must be enough water to satisfy the requirements of the crop. A city can continue to function only as long as water is being supplied to the water-dependent urban functions (households, schools, hospitals and industries). For example, the city of Bulawayo in Zimbabwe was close to evacuation during the 1992 drought.

31. For the second reason, land use and the manipulations of soil and vegetation that it involves influence the essential determinants of water flows and pathways through a landscape, both above and below the ground. Land use also involves the handling of waste, resulting in an output of chemicals to the ambient atmosphere and polluting the water circulating through the landscape in the water cycle. In fact, most pollution of coastal waters originates from land-based sources.

C. Negotiable issues

32. In contrast to the non-negotiable phenomena that govern the general behaviour of water in the landscape, man's relation to that resource is more or less negotiable. Human ingenuity has developed considerable degrees of efforts to make the best within given non-negotiable constraints. Four key components influence societies' interaction with existing water constraints:

- (a) Expectations and lifestyles determining water requirements;
- (b) Technological arrangements to mitigate variability in time and space;
- (c) Administrative arrangements to regulate human interactions with water;
- (d) Societal capability/skills to manage land use and water resources.

D. Particular regional problems

33. Water-related preconditions and problems are subject to considerable regional variations in terms of environmental preconditions for human activities, as follows:

- (a) Some regions have marked seasonal differences in rainfall, while others have year-round precipitation;

(b) Some regions have highly permeable soils that allow the rain to infiltrate and form groundwater, while others are almost impermeable, so that the rain forms rapid floods;

(c) Some areas are located high up in the landscape where the vegetation is rain-fed, while others are low-lying and the vegetation is fed by capillary rise of groundwater and by inundated water;

(d) Some areas have a high evaporative demand and a run-off highly vulnerable to vegetation changes, while others have low evaporative demand and the hydrological effects of vegetation changes are barely detectable.

34. Superimposed on such naturally existing differences are cultural differences based on societal aspirations, lifestyles, population pressure, urbanization etc. that vary from region to region.

35. Man-made environmental problems are also subject to a considerable number of regional variations, as follows:

(a) Dry topics: land degradation, waterlogging and salinization of irrigated croplands, and bacterial pollution from human waste;

(b) Dry temperate regions: waterlogging and salinization, chemical pollution from industrial waste and eutrophication from overfertilization in agriculture;

(c) Humid tropics: degradation of deforested lands, chemical pollution from mining and other industry, and bacterial pollution from untreated sewage;

(d) Humid temperate regions: forest dieback from acid rain, chemical bombs and the pollution legacy of previous generations, eutrophication from overfertilization and chemical pollution from industrial waste.

36. A recent overview 10/ summarizes the current predicament as follows:

(a) Information on the resource is vastly inadequate; there is no reliable assessment of the human impact on the resource;

(b) In cooler regions, new water resources development measures are met with broad public scepticism, while arid regions are fundamentally dependent on such measures;

(c) In arid regions, climatic conditions involve large vulnerability to human impacts on soil and vegetation;

(d) Degradation of water quality threatens to become an almost unmanageable crisis, especially in the developing regions, where both chemical and microbiological pollutants create problems. The developed regions have largely failed in their source reduction efforts, except for a few pollutants;

(e) Agriculture is confronted with regional water scarcity, which constrains current goals of achieving food self-reliance and socio-economic development. A more fundamental adaptation to water constraints is called for;

(f) In the energy sector, water is required for almost every aspect of energy production and use. In dry climate regions, energy choices will therefore be influenced by the limitations of water availability.

III. WHAT IS TO BE DONE?

37. The simplistic water resources management models of the past, which have led into the current dangerous dilemma, will have to be modified. The sector-wise approach to water, ignorance of natural resource issues in governance circles, and a fragmented administration attempting to link activities that are interdependent but not provided for by legislation face huge bureaucratic difficulties. What is needed is no less than a water management revolution. The role and place of water in the socio-economic system varies from country to country: therefore, there is no standard solution. Efforts to avert the critical situation must focus on two parallel goals: improving everyday life and living conditions for poverty-stricken and famine-prone populations, and long-term planning for an environmentally sustainable future. A proper balance has to be struck between curative and preventive action: finding a remedy for the symptoms of past mismanagement while at the same time avoiding future calamities linked to societal driving forces.

A. Water management revolution

38. In broad terms, in international negotiations decision makers and diplomats should:

(a) Develop an overall insight into the role of water in the development strategy of the country, and propose and defend on the political level a strategy for the sustainable use of the nation's land and water resources;

(b) Enable, wherever water is scarce, a philosophy of maximum productivity per unit of water;

(c) Enable the formulation of an integrated water management plan that establishes a course of action involving natural and human resources in a given watershed, including social, political, economic and institutional considerations. Natural and human resources should be identified, development options evolved and impacts assessed in such a way that political decisions can be made. Typically, such a process should include (i) assessing the hydroclimatic, hydrographic and demographic conditions; (ii) establishing water management objectives; (iii) formulating and evaluating alternative resource management actions, implementation tools and institutional arrangements; (iv) assessing the impacts of promising alternatives; and (v) choosing and implementing the preferred course of action.

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39. The patterns of water needs and demands will have to change considerably in many countries. It is useful to distinguish between (a) supply management, seeking a supply adequate for a set of water needs and including the traditional activities required to locate, develop, and exploit existing and new sources of water, and (b) demand management, concerned with the ways in which water is allocated and used, the socio-economic and environmental effects of that use, and the various tools available to promote more desirable levels and patterns of use.

40. Projections about growing demands and needs for water raise the question of technological options. It is often argued that contemporary technology enables us to transfer water from surplus to deficit areas, and also to reuse and recycle water almost indefinitely. A point will sometimes be reached at which it will make more sense to import the required food (virtual water) instead of importing the (real) water needed to drought-proof a given crop production. As to supply management, the availability of cheap and environmentally acceptable energy may help resolve supply problems through water transfer, groundwater pumping and desalination. ^{11/} The high costs of desalination, however, confine that option to uses of water with a high economic value, although with time improvements may extend its possible range.

41. Water purification techniques also have a role to play, since they facilitate water recycling and reuse. Systems, practices and products that reduce water contamination are required not only to protect the environment but also to increase water-supply options. There is also the option of having several water distribution systems with different levels of quality and different prices so as to reserve high-quality water for uses that require it.

42. Demand management can be described as a coherent set of actions and tools that can be used to implement the levels and patterns of water use required for meeting desired objectives. Technical tools are mostly applied to directly affecting the way in which water is used, through direct regulation or through changes in technology, operation or voluntary behaviour. Reduction in water losses in transport and distribution is an important part of any demand management plan. Demand-side management schemes include the diffusion and promotion of devices and systems that use water more efficiently, including water-saving innovative industrial processes. A wide range of low water use devices and technology is available, numbering in the hundreds of individual techniques, fixtures and devices. The application of a variety of demand-side management schemes for energy adopted by electric utilities in several countries could be studied, especially for the domestic and service sectors, drawing from the very substantial experience accumulated in that field.

43. With irrigated agriculture claiming two thirds of all the water removed from rivers, lakes and aquifers, making irrigation more efficient is a top priority in moving towards more sustainable water use. A wide variety of measures exists to improve agriculture's water productivity, such as new and improved irrigation technologies, and better management and cropping pattern practices by farmers and water officials, backed up by changes in the institutions that govern the distribution and the use of irrigation water. Field experimentation on innovative irrigation schemes is required to qualify such schemes for the actual conditions of application in different countries.

B. Strategies for sustainable land/water management

44. Sustainable management basically aims at successfully and sustainably coping with environmental preconditions while satisfying societal needs.

45. This means developing a strategy towards non-undermining land/water management, paying attention to the complexity of water-related issues by successfully balancing the different functions, sectors and stakeholder groups internally. For the next generation of water resources management efforts, it is essential to realize that the water passing through a landscape with its settlements and artefacts is involved in a whole series of parallel functions (health, habitat, production, carrier and psychological). Such different functions are often linked to separate societal sectors driven by different political goals, have different groups of stakeholders, and are managed by different administrations.

46. Planning and decision-making in a river basin or a management unit must be placed in the framework of a system in which all components are related: to evaluate any one of the components in isolation is to omit the impact on the broader goals of a society or a nation. An integrated approach, which takes into account all relevant factors and involves all those who are active in such fields in order to get broad support and commitment, is indispensable.

1. Avoiding overexploitation of groundwater

47. The use of groundwater - often the only reliable resource in semi-arid regions - has to be adapted to the aquifer's sustainable yield in order to protect the land from subsidence and the economy from undermining and long-term decline. This is particularly important in coastal areas to ensure that groundwater does not become unusable due to irreversible intrusion of saline water into the aquifer.

2. Non-polluting land use

48. In water-scarce regions, it is particularly essential that passing water be carefully protected from quality deterioration from waste-producing land use, which makes the water hazardous for water-dependent activities in the region. In other words, land use has to be managed so as to avoid incautious waste-handling and other polluting activities that might expose the water to quality degradation. Protection of underground water resources from pollution, especially of an organic nature, is particularly important, because their isolation from the atmosphere effectively reduces the possibility of self-purification through aerobic mechanisms.

3. Land fertility to be safeguarded

49. In view of increasing global concerns for food security for the rapidly growing world population, it is essential to minimize land fertility

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degradation, which undermines the potential for food self-reliance as a result of poor land policies or poor irrigation management.

4. Proper attention to cross connections

50. Due to land/water linkages, it can be stated that land-use decisions are actually water-use decisions as well. Proper management therefore demands that the two be integrated, at least in the sense that land-use management must have a water component and water management must have a land-use component. For example, in order to protect water from quality deterioration efforts must often be focused on land-based pollution sources. Ways should therefore be developed by which it will be possible to orchestrate ^{12/} the enhancement of life-support systems by careful control of the environmentally degrading landscape manipulations involved in harvesting natural resources (water, energy, food, fuelwood, minerals). Attention should be paid to the so-called tyranny of micro-decisions that result in local changes in the landscape, with consequences which, when added up and integrated, may produce unacceptable conditions and degradation of life-support systems.

5. Balancing between conflicting objectives

51. The way in which water is allocated among competing uses or classes of water users is the determining point of interest when adopting the demand approach to the development of a management framework. In order to come to a justifiable solution of the problem, it is essential to have a clear identification of the (conflicting) objectives at stake, as well as of the users to be served and their positive or negative contribution to meeting the needs of all objectives.

52. The evaluation and ranking of alternative solutions for the allocation problem, therefore, must be based on a number of objective criteria, including objective factors, such as impact on economic indicators, patterns and rates of growth of population, quality of life, coverage of service offered, reduction of new supply costs, and impacts on water quality.

6. Integrated approach

53. Serving human activities with water calls for an integrated approach at the level of river basin or drainage basin. Strategies must therefore make such an approach possible, integrating interrelated phenomena, such as upstream water-impacting activities and downstream water-dependent activities, as well as land use and water management. From a water allocation perspective, water in aquifers and rivers has to be shared on three complementary levels: (a) local sharing between water-dependent sectors and users (households, industries, irrigated agriculture); (b) urban/rural sharing; and (c) upstream/downstream sharing by sequential reuse. At the same time, strategies should include deliberate methods of pollution avoidance to ensure sequential reuse of resources.

54. The integration between land and water should preferably also include waste management to protect water from being polluted. Key components are water resources development, supply systems, demand management, waste management restrictions and waste-water treatment. When translated into its implications in a societal context, such integration between land use, water management and waste management should also be reflected in the approach to human health, nutrition, employment and ecosystem health.

C. Human capability development

55. The management revolution must be supported by education, training, empowerment and responsibility sharing in order to develop the human capability needed to address the new challenges in terms of complexity and interactions, fill existing gaps in terms of deficiency of trained manpower, and produce new cadres of professionals that are better trained and empowered in addressing complexity. ^{13/} Education is essential, but only if educated professionals are given the power to implement the management measures decided upon. In addition, awareness-raising campaigns among both politicians and the general public are also called for: the public should be given the chance to understand the risks they are taking, and not merely left to do so.

IV. HOW IS IT TO BE DONE?

56. Implementation of the action needed and discussed in section 3 above is not a matter of merely giving an order to a group of civil servants and engineers. Training and capacity-building is necessary but not enough. An enabling environment should be created to initiate the necessary cooperation and preparedness of all sectors and actors involved in the process, even if for some of them there will be the threatening prospect that they may lose a monopoly. Institutional support at the political level will be a prerogative for a successful undertaking. A set of clear actions are suggested below for enabling such a process. Experts are well aware of technicalities but must be offered the right instructions, organization, structures for coordination, institutions and legislation to achieve an integrated approach.

57. National policies will evidently be greatly affected by climatic region and state of economical and social development. For example, the urban water-supply in South-East Asia is vastly different from the water-supply in Europe, although the same principles apply.

A. Defining constraints

58. Hydroclimatic and hydrographic constraints must be evaluated and taken into account in land-use planning. Without access to household water, inhabited areas have no future. Industrial areas also depend on water supply for water-dependent industrial processes. And in dry climate regions, successful agricultural yields are critically dependent on access to protective irrigation during drought periods. In water-scarce regions, the possibility of drought-proofing the crop production must however be coordinated with other uses of

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passing water (municipal uses, industry, hydropower). The water passing through a particular river basin, in other words, must be shared between upstream and downstream users, as well as among societal sectors. Wherever water is scarce, water demands must be minimized and water productivity maximized.

B. Management tools

59. Management tools available for the implementation of the complex land/water/waste management necessary in order to avoid the current undermining of human life-support systems include:

- (a) Legislation consistent with the laws of nature;
- (b) Hierarchical administrative systems that allow an intersectoral approach and dialogue, and are capable of handling complexity without bureaucratic paralysis;
- (c) Education at all levels of society.

60. The Government must:

- (a) Develop the legislation and regulations that make regional planning possible;
- (b) Define national objectives and targets to secure development within the constraints of prevailing environmental conditions and vulnerability;
- (c) Secure the necessary legislation for waste minimization, together with enforcing rules and regulations.

61. Demand management measures are also evaluated in terms of public policy, user requirements and environmental requirements. In developing demand management policy, a water agency must choose among combinations of numerous legislative, regulatory, technological and behavioral measures, each with a unique set of advantages and disadvantages. Incentives and sanctions are important to support demand management.

C. River basin oriented action plan

62. Although much action must generally be taken at the local level, actions must also fit into an overall regional plan, manifesting a joint programme for a river basin or management unit. The river basin plan offers a clear opportunity for balancing different interests, and even for striving to achieve visions shared among key stakeholder groups. Emphasis should be directed to:

- (a) The evolution of an integrated land/water-oriented action plan to achieve a balanced development of the river system, taking into account all relevant factors (demographic changes, ecological, socio-economic, hydrologic and hydraulic factors, and spatial and agronomic potentials of the basin) and

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ensuring proper attention to urban/rural and upstream/downstream competition for water;

(b) Stimulating environmental awareness and institutional strengthening inside the subject ministries and non-governmental organizations concerned in order to obtain support for such an integrated water-oriented planning and to promote the effectiveness of the decision-making process.

63. An effective action plan should at least cover the following features:

(a) A clear set of objectives to be achieved and potentials to be developed in a well-defined period of time. If necessary, various phases can be indicated to make an acceptable and realistic progress towards possible goals;

(b) The physical, socio-economic, environmental and institutional systems influencing objectives;

(c) The disciplines involved in the formulation of the action required, its implementation and the monitoring of the progress towards objectives;

(d) An inventory of all relevant factors in the existing situation as starting and reference points;

(e) Clear indicators to monitor progress made;

(f) Clear description of actions and appointment of actors responsible for implementation.

64. Procedures are available for the systematic consideration of demand-management measures, and for their integration into demand management plans. When followed carefully, such measures can identify and discard plans that fail to achieve all objectives satisfactorily, or that achieve objectives at a unnecessarily high cost. The development of alternative plans allows consideration of trade-offs among objectives or among different allocations of impacts across geographical areas of user classes.

D. Financing modes and economic incentives

65. Two guiding principles were recommended by both the International Conference on Water and the Environment and Agenda 21:

(a) The polluter pays principle;

(b) The principle of water as an economic good.

The polluter pays principle basically refers to the allocation of water in aquifers and rivers. In the long run, it will have to be given an expanded connotation to include the water consumed in rain-fed biomass production as well, since such return flow to the atmosphere represents water that is not available for reuse.

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66. Water use responds to economic incentives that can be implemented either by using a tariff structure or by providing incentives for sound and responsible behaviour. Tariff design procedures in domestic and industrial water supply distinguish between the economic incentives provided by prices and revenue collection. Proper choice of tariff elements permits designs that promote efficient and resource-conserving use of water and support a range of income redistribution goals while collecting the necessary revenues.

67. Incentives can be provided through a variety of methods. In the case of domestic demand rebates may be given to water users who commit themselves to voluntary quotas. In addition to the implementation of licensing systems, industrial users can be encouraged to contribute to water management goals by means of tax rebates on certain recycling and waste treatment equipment, high-use surcharges and penalties for discharging pollutants. The control of water use in irrigated agriculture can be addressed in various ways, such as levying penalties for water use in excess of water requirements projected for the next growing season, or by promoting the adoption of more efficient irrigation systems to replace the traditional techniques, for example, by making available low-interest loans contingent on the purchase and installation of improved irrigation equipment.

V. WHO SHOULD DO IT?

68. The implementation of the strategies described above will involve several groups of actors from the international level all the way down to the water user. Agenda 21 stresses the interaction between the formal and informal systems, including the private sector. Action at the governmental and intergovernmental levels, in particular, is addressed below.

A. Governments

1. Three main roles of government

69. Water resources are generally recognized as a major determining factor for the socio-economic development of a country. The close relation between water resources development and socio-economic development lies in the Government's role in creating an enabling environment for the desired national development process and making use of its natural resources in a sustainable way, i.e., without undermining the resource base. The Government has a number of roles, each justifying a different type of engagement:

(a) The Government as creator of an attractive environment for the natural development process, in which water is a major determining factor;

(b) The Government as responsible actor for environmental policy-making. The Government should develop strategies for non-undermining land/water/waste management;

(c) The Government as provider of services, such as certain water services, capacity-building, monitoring and conflict mitigation.

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70. Agenda 21 recommends as a basic management principle taking action at the lowest appropriate level, in other words as close to the actual level of activity as possible. The Government must provide a hierarchical framework that makes such management possible. Governments should therefore set up mechanisms for basin-wide management in order to make an integrated approach possible on the river basin level.

2. International agreements

71. Especially in view of the non-negotiable hydrographic constraints defined by geographic facts (see fig. II), many countries are mutually dependent on the water resource of a shared river basin or aquifer. An international code of conduct for water-sharing was called for as early as 1977 in the Mar del Plata Action Plan. Today, almost 20 years later, an international code of water ethics is even more urgently needed to guide countries in their efforts towards bilateral and multilateral agreements on how to best benefit from the water passing through the river basin. With the need to intensify biomass production to feed a rapidly growing world population, we are approaching an even more delicate question: how to share the rain over the river basin with neighbouring countries?

B. United Nations

1. Main roles of the United Nations

72. Whereas Governments have the responsibility of facilitating water-related activities in their countries and safeguarding water resources in order not to undermine their development efforts, the United Nations is expected to facilitate Governments' actions by addressing cross-national problems and by maintaining a general and comprehensive overview for preventive purposes.

73. There are a number of other cross-country activities that the United Nations will be expected to take responsibility for, such as:

- (a) Monitoring global water resources;
- (b) Conflict mitigation, in particular third-party support of bilateral or multilateral negotiations over shared water resources;
- (c) Securing research on survival issues, such as the intensification of rain-fed agriculture in dry climate regions with rapid population growth and therefore a rapidly growing life-support burden;
- (d) Evaluation of development strategy formulation;
- (e) Evaluating preconditions for sustainable development;
- (f) Creating preparedness for the environmental migration, which is expected to escalate.

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2. Address increasing regional imbalances

74. The United Nations should urgently take the initiatives needed to avert the imminent water crisis. An interesting model for the needed diagnosis worldwide could be the Intergovernmental Panel on Climate Change.

75. Issues of worldwide relevance include the implications of water scarcity for regional development, in view of the problematic environmental preconditions that such scarcity implies. Such linkages need to be seriously considered by the United Nations - the Special Initiative for Africa provides one opportunity. Unless a new agricultural revolution is envisaged in the near future that would radically reduce the amount of water consumed in food production in hot countries (currently about 3,000 cubic metres per ton of grain produced), it must be acknowledged as an urgent matter that there seems to be a definite limit to the human population that can be supported by the available water-supply.

76. The United Nations might even be motivated to analyse the situation of the Organization itself in relation to development strategies for third world development. A key issue is how to generate new positive spirals, such as the green revolution of recent decades, without undermining life-support systems or generating a continuous dependence of poor countries on continued international support and/or charity. Indeed, one way the United Nations could address the increasing imbalance between the supplying and the supplied regions of the world would be to convene a global conference on human survival on the threshold of the century.

3. Equitable share - of what?

77. The United Nations should also promote international understanding and cooperation on the integrated management and development of water resources, which might involve the formulation of an international convention on freshwater resources along the lines of existing conventions on biodiversity, ozone depletion, climate change and other fields of relevance for the future of humanity. In particular, the United Nations should develop principles and ethics to guide the world's nations in sharing the joint planetary freshwater resources, developing the global strategies needed to achieve socio-economic development in a way that does not undermine the life-support systems on which it depends, and safeguarding global food security. Safeguarding freshwater resources so that they remain available for the next generation as well makes the non-depletion of groundwater resources an intergenerational issue.

78. Probably the most crucial issue of all to be addressed by the United Nations is how the finite amount of freshwater circulated around the globe in the water cycle should be shared by humanity.

79. By applying the central environmental concept "Think globally, act locally" to the equitable sharing of freshwater, the joint resource to be shared by all countries on an equitable basis would be freshwater evaporated from the high seas, which would conform with current concepts of global sharing - even by land-locked countries - of the mineral resources of the high seas. 14/
Developing rules for such equitable sharing, however, would probably take even

more time than the quarter of a century needed for the efforts of the International Labour Organization to formulate rules for sharing the flow in international rivers.

80. Thus, a more realistic strategy in relation to freshwater would be "Think regionally, act locally", encouraging Governments to accept hydroclimatic and hydrographic constraints and to develop river basin action plans in which local activities and projects are seen as fundamental components.

4. Global water assessment initiated by the Commission on Sustainable Development

81. As follow-up to a decision made by the Commission on Sustainable Development in 1994, a United Nations-supported comprehensive global water resources assessment is currently being conducted jointly by the relevant United Nations bodies and the Stockholm Environment Institute. That initiative represents one of the necessary actions expected to trigger activities by Governments and help to bring about the changes needed in water policy. The General Assembly should be invited to prepare itself for rapid action in response to that assessment, which is to be submitted to the Assembly at its special session in 1997 to review the implementation of agreements made at the United Nations Conference on Environment and Development.

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